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DRYCLEANING OF FINE AND FRAGILE TEXTILES

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SECTION I. General Facts About Drycleaning.

In this brief technical paper we hope to provide textile conservators with principles and technology of drycleaning which will enable them to employ it safely and advantageously. To do this, a number of questions and discusions thereon are presented herewith which are expected to cover the subject. In a logical development, these follow:

1) What is Drycleaning?

Actually it is soil removal by organic solvents or liquids. It should not be confused with air cleaning or macro dust removal by air or gas blast. In earlier articles in this series in connection with soils and wetcleaning principles (No. IV and No. V)[1] it has been mentioned, especially where various solvents were concerned. A more specific discussion of these solvents follows in a later section herein.

While not precisely defined in the above references, wetcleaning may be described as a cleansing process employing water and substances soluble in water using precautions to prevent shrinkage, loss of color and prevention of fabric distortion.[2]

2) How Does Drycleaning Resemble Wetcleaning?

The two processes are alike because both depend fundamentally for soil removal on dissolving, softening, emusifying, suspending or floating away of foreign and unwanted particles or deposits. To do this both processes require assistance in wetting and penetration in breaking up massed deposits and in suspending and the removal of the smaller particles from the cleaning scene. Thus for drycleaning we need time of contact, mechanical action, help by additives such as special surfactants and limited moisture, rinsing, extraction and drying in the same general ways and for the same reasons as in wetcleaning; while temperature effects, which are so important in wetcleaning, play some part in drycleaning, they must be rigidly controlled for safety and other reasons as will be explained later.

3) How Does Drycleaning Differ from Wetcleaning?

There are four principal differences:

a. Drycleaning solvents dissolve oily fatty substances which are not soluble in water. On the other hand, they do not dissolve water soluble substances such as sugars, starches, salts and other polar compounds except under special humidity conditions to be discussed in detail below. Notably drycleaning solvents do not affect most of the natural dyes and this is the reason why drycleaning is a valuable tool for conservators where wetcleaning bleeds certain colors. Drycleaning solvents may, however, dissolve some modern synthetic dyes such as are used for coloring many of the synthetic fibers. They also may dissolve oil mordanted colors similar to wax crayons.

b. Drycleaning solvents and water do not mix or dissolve in one another to any great extent. However, minute quantities of moisture can be absorbed by a solvent from the air. The amount of moisture absorbed in this way is quite limited and depends on how much moisture the air is carrying in proportion to how much it could carry when saturated. This is by definition the air relative humidity and, as an example, if it is 60%, the solvent will only carry a proportional part of its total capacity. This is called the *solvent relative humidity*.

In similar fashion, fibers and other hygroscopic substances will change in moisture content according to the relative humidity of the air and, if submerged into a solvent, will adjust moisture content with that of the solvent until an equilibrium is attained.

In the case of the fibers this gain or loss of moisture from the surroundings is called "regain" or sometimes natural moisture content, (NMC.), depending on the basis from which it is calculated.

This peculiar exchange of moisture has a profound influence on soil removal by drycleaning solvents and will be treated in detail later.

c. Water swells natural fibers, drycleaning solvents do not. This characteristic behavior is important because fiber swelling is one of the major causes of shrinkage.

Swelling also results in promoting release of dyestuffs and subsequent bleeding or dye loss. Where the drycleaning solvent is not saturated or "over charged" with moisture, swelling is minimal. However, if the solvent relative humidity is near saturation or if it contains emulsified water droplets, in which case it would be over-saturated, the chances of shrinkage would be greatly increased.

d. Water is an ionizing medium and as such is able to promote the action of certain chemically reactive substances such as acids, alkalies, oxidizers, reducers, digesters and sequestrants. Water also, because it may ionize in its own right, may enter into reactions with dyes and fibers.

The drycleaning liquids have no ionization powers and are not ionizable, and thus neither promote nor ordinarily enter into chemical reactions with the natural fibers or dyes.

It is possible that certain special organic solvents may penetrate and dissolve or damage some of the recently produced synthetic polymers such as cellulose acetate, nylon and others. As a rule, however, the more widely used commercial drycleaning solvents do not affect the fibers just mentioned. However, the elastic rubber fibers are usually weakened by these drycleaning solvents.

Modern dyes that are especially designed for otherwise densely compacted synthetic fibers are sometimes attacked by the drycleaning solvents, especially at higher temperatures. These dyes will probably never be encountered in historic fabrics except in unusual cases of patching, mending or in supporting fabrics.

4) Under What Circumstances is Drycleaning Especially Recommended?

a. Tarry, waxy, oily or greasy soils will usually respond to drycleaning solvent action with less mechanical manipulation and at lower temperatures than if the fabric is wetcleaned.

b. Drycleaning is generally safe for goods containing fugitive colors or that have been poorly processed in the dyeing. Fabrics such as batik, old weighted silks, modern Navajo blankets, old hooked rugs and many old highly colored prints will not withstand wetcleaning but will dryclean satisfactorily.

c. Very old and greatly oxidized fabrics may be drycleaned and dried with less additional oxidation likelihood than if they are wetcleaned. In water removal, unless the drying conditions are closely controlled and are very rapid, further oxidation is probable.

d. Certain fabric constructions such as velvets and plushes may become crushed and difficult to restore after wetcleaning. Drycleaning usually does not adversely plasticize such pile goods. Various special finishes such as embossed chintzes and starched effects may be lost in wetcleaning but will stand up to drycleaning. Likewise, protein or animal type glues are unaffected by drycleaning.

e. Padded composite constructions such as quilted fabrics often contain hazardous hidden materials in the padding. Wetcleaning may cause bleeding of coloring substances from cotton linters for example or from frayed yarns and other waste from the interior stuffing to the surface. This sometimes results in unsightly unremovable stains. Such goods may be drycleaned safely.

f. Feather and fur trimmed articles can usually be drycleaned and later treated with nonaqueous lubricants and preservatives. Wetcleaning is often harmful in this case.

5) When is Drycleaning Not Advisable?

The several main cases in which drycleaning may be an unwise choice are worthy of emphasis.

a. Painted or printed art work and decorations that are pigments depending for adhesion on drying oils are probable hazards.

b. This admonition also applies to modern adhesives, especially the rubbel-like flexible mending type compounds sometimes used for reinforcing rugs and tapestries. Not all modern "glues" are affected but all should be tested and observed in miniature before drycleaning is chosen.

c. Foam rubber padding as in cases of repairs to upholstery may be damaged or destroyed by drycleaning.

d. Bleaching, pH control, digestion, and other incidental special cleaning operations are not practical in drycleaning media.

e. Fabrics that have been soiled by finely divided earthy or clayey matter as from muddy water or redeposited soil from mismanaged cleaning practices do not respond well to drycleaning. In this connection wool and silk behave better than cotton goods.

SECTION II. Solvents for Drycleaning.

1) What are the Principal Characteristics of a Drycleaning Solvent?

There are at least five qualities that are necessary in an organic liquid if it is to do the required cleaning work:

a. The liquid must be a good soil remover. This means that it should dissolve, penetrate or suspend well, many foreign deposits and substances.

b. The liquid should not react adversely with the substrate. This means that solvents such as acetone that will dissolve cellulose acetate or certain alcohols that may cause some dyes to bleed would not be accepted for general drycleaning work.

c. They should be low in toxicity. In this connection, the effect of drycleaning solvents depends a great deal on the individual user as will be mentioned again later.

d. The solvents should be safe from the point of view of fire and explosion hazards. In this connection, regulations and allowances have been adopted by many local governments and insurance organizations that define conditions of use and safeguards which if followed may be considered as safe and permissible practices from this point of view.

e. The solvent should be reasonably cheap. This is necessary because for historic or fragil textile cleaning it may not be convenient to reclaim used

solvent and thus the liquid may have to be discarded.

2) How are the Organic Solvents Classified?

For cleaning personnel there are two main groups, the drycleaning solvents and the special solvents. Both have been mentioned in a previous paper in which soils were discussed.[3]

There are two types of drycleaning solvents in widespread use by professional cleaners, the petroleum distillates and the synthetic or man made solvents. Of these only a few are recommended for use in conservation work.

3) What are the Characteristics of the Approved Petroleum Distillates?

The petroleum distillates are special fractions obtained from crude mineral oils in the refining processes.

Crude mineral oil is composed of many different carbon compounds, principally of long chains or paraffinic types. Some of these, however, contain cyclic groups of naphthenic or aromatic structures that modify the straight chain molecule and its behavior. In the refining process, these paraffins and similar compounds may be separated by careful selective distillation and various chemical processes to produce special products that have good cleaing properties, are low in toxicity, relatively safe from explosion and fire hazards under reasonable use conditions, produce no lasting bad odors, and are unlikely to form objectionable residues.

Two common products with these qualities have been adopted by the drycleaning industry after much technical development. These are Stoddard solvent and "High Flash" solvent, which differ principally in the ignition temperatures at which their vapors will ignite.

In explanation, the vapors of Stoddard solvent according to specifications will not ignite or explode in air at ordinary pressures below 100° F. Under the same pressure conditions "High Flash" solvent will not explode when mixed with air until the temperature exceeds 100° F. A most common and popular grade is one that is known as 140° F. flash solvent and which this author favorably recommends.[4]

Either of these two grades are suitable for cleaning all textiles, except those containing rubber, oil paints, wax deposits or special flock adhered decorations, that must be preserved, and a few very special modern textiles and unusual lately developed apparel constructions such as laminated cloth.

The petroleum solvents are slow in cleansing action when compared to many other less desirable solvents. As a consequence, they may require much longer exposure time and more mechanical action. They are, however, unusually good solvents for fresh or unpolymerized oils and greases and reasonably fresh oil paints. When mixed with a "dry cleaning detergent" and a little water, they will dissolve or solubilize some wet cleaning soils.

They present the lowest toxicity hazards of any liquids used in drycleaning. The reason for this is that the vapor pressures are so very low that not enough fumes are evaporated into the air under ordinary use condition to endanger personnel except to individuals who have a specific physical intolerance to the chemical. This is exceedingly rare.

The low vapor pressures associated with these petroleum solvents affects their drying rates. Thus we find that they dry very slowly and if steps are taken to remove the last traces of the solvent by use of air, we must use comparatively very great quantities of fresh warm air and keep the conduits free of lint, in order to minimize explosion hazards. Otherwise evaporation of the final traces of solvent will take a long time.

Under forced drying conditions, the natural fibers are usually over-dried and as a consequence the natural moisture is reduced to a point where the fabric feels harsh and brittle. Under natural regain conditions, the fibers do not return quickly to a satisfactory flexibility and physical condition immediately so that a false impression of damage is often imagined. The harshness may be overcome rapidly by gentle and careful steaming or by a fine mist water spray.

The petroleum solvents are relatively cheap if purchased in quantity from dealers in cleaning supplies or fuel supply agencies. If purchased from supermarkets, department stores and other suppliers under trade marked names, they will be priced at about eight or ten times in mark-up.

In general, the petroleum distillates are formed of stable saturated compounds that do not polymerize, oxidize or hydrolize easily. As a consequence, objectionable residues or reactions with natural fibers are unlikely.

Some petroleum or similar distillation products that are excellent cleaning fluids which are *not* recommended for textile cleaning purposes are gasolene, naptha, kerosene, benzine or lighter fluid and coal tar distillates and mixtures thereof.

For trade names and suppliers of a recommended petroleum type solvent see Appendix I.

4) What Classes of Chemicals Constitute Synthetic or Man Made Drycleaning Solvents?

The synthetic solvents are organic chemicals that are not found in nature. There are two closely related chemical families that provide successful drycleaning agents but only a few members of each family are recommended. These two groups are the chlorinated hydrocarbons and the fluorinated hydrocarbons.

The generally approved chlorine hydrocarbons in widespread use today that have been studied and proven as drycleaning fluids are perchlorethylene (or tetra-chloro-ethylene) (C_2Cl_4) and a near relative trichlorethylene (C_2HCl_3).

Perchlorethylene has had wider acceptance in the United States for various reasons that will be brought out, than trichlorethylene which has been, until recently more popular in Europe, probably because of price differences. Recent advances in manufacturing technology, however, have overcome this factor and we understand that perchlorethylene is gaining wider acceptance in that area.

Although these two solvents are very much alike in properties, perchlorethylene is slightly superior in a number of respects.

From the cleaning point of view both of these solvents rate as faster acting in grease removal than petroleum types. They also attack and suspend other difficultly soluble soil masses more readily. This is probably because they are about twice as heavy as the petroleum mixtures and at least half again as heavy as water. Table I illustrates this point.

TABLE I

Significant Data

Solvent	Formula	B.P. °F	Flash Point °F	M.A.C. ppm	Sp Gr
Stoddard Solvent	Mixture of many hydro-carbons	320 410	100°	500	.7-.8
140° F Solvent	"	358 415	138°	500	.7-.8
Perchlor-ethylene	C_2Cl_4	250.2	none	100	1.62
Trichlor-ethylene	C_2HCl_3	188.4	none	100	1.46
Trichlor-trifluor-ethane	CCl_3CF_3	118	none	1000	1.5 ap-prox.

One solvent in the second group of synthetic liquids, the fluorinated hydrocarbons, that is being marketed today is Valclene* a trade-marked cleaning fluid which is composed chiefly in trichlor-trifluor ethane (CCl_3CF_3). This chemical, as the name and formula show, is not precisely a fluorinated hydrocarbon only. The trifluorine group, however, modifies some of the behavior patterns of the molecule profoundly.

It is a very fast cleaner, rating perhaps equal to perchlorethylene. This may be because it is about the same specific gravity.

From the point of view of effect on dyes and colors, it is said to be less likely to cause bleeding and in that respect is claimed to be in the same class as the approved petroleum solvents.

Toxicity of the Synthetic Drycleaning Solvents

One of the greatest objections to the synthetic solvents in drycleaning generally is the matter of their toxicity.

In general, these chlorinated compounds have anesthetic or numbing effects on the body and may produce permanent damage by cumulative action on the liver and kidneys. Of the two drycleaning solvents most widely used, perchlorethylene and trichlorethylene are considered as intoxicating mainly without pronounced cumulative properties. On the other hand, carbon tetra chloride CCl_4, which has been used as a drycleaning solvent in the past, is rated as a very dangerous cumulative poison. Chloroform, $CHCl_3$, a widely used spotting and paint removing agent or ingredient, is rated as slightly less dangerous than the CCl_4.

In dealing with drycleaning compounds we are chiefly concerned with those that enter through the respiratory system. Those affecting the lungs are in the form of vapors and, in this case, the amount of a toxic in the air will depend on its vapor pressure, the temperature and how much fresh air is available to mix with and dilute it.

For purposes of approximate comparisons, the boiling points of the various solvents are indicative of the vapor pressure if compared at any one temperature. This is an inverse relationship. Thus, a high boiling point would indicate a low vapor pressure. To illustrate: perchlorethylene, boiling at about 250° F would produce a lower concentration of vapor at 68° F (assumed normal comfortable temperature) than trichlor-trifluor-ethane, the boiling point of which is nearly 118° F. In this case, it would be possible to produce a very high concentration of the CCl_3CF_3 compared to C_2Cl_4 at this temperature in a confined and unventilated space.

There are two other characteristics of volatile substances to be carried in mind when evaluating a solvent as to its dangers to personnel. First, how does it affect the body, and second, is the body able to destroy or eliminate the poison so that it does not build up and permanently damage the tissues of some specific organ such as the liver?

Generally, intoxicants or anesthetics in low concentrations are usually noncumulative, whereas other types may damage various organs irreparably. In this event, the effect may be cumulative and increase with the number of times exposed. Unfortunately, some otherwise excellent cleaning solvents such as carbon tetrachloride, CCl_4, or chloroform, $CHCl_3$, have both effects. These are not recommended except for special cases under carefully controlled safety conditions.

There are several ways of comparing the toxicity of compounds under discussion, but perhaps the best system as far as textile conservators are concerned is the "threshhold limit value" recommended by The American Conference of Governmental Industrial Hygenists.[5] This refers to time weighted average concentrations for a normal 8-hour workday and represents conditions under which it is believed all workers may be exposed day after day without adverse effect. These data for the several solvents discussed are listed in Table I.

The maximum allowable concentrations reported

are (1) in parts of the toxic in a million parts by volume of air or (2) by milligrams per liter. The first method is useful for comparing data for working conditions whereas the second is valuable for estimating total harmful dosages.

The dosage necessary for producing a damaging effect depends on two things: first, the virulence of the chemical, and second, how strong is the resistance of the person affected. This will vary according to particular general health and well being of the person at the time.

Of the three recommended synthetic drycleaning solvents, we would rate trichlor-trifluor-ethane with a M.A.C. (maximum allowable concentration) of 1000 ppm as quite safe, even though it is highly volatile and such a concentration is more easily attained than some of the others.

Perchlorethylene, although rated at M.A.C. 100 ppm according to the Table, is considered a safe industrial solvent because it is much less volatile than the CCl_3CF_3. The C_2Cl_4 is presently in daily use by thousands of professional cleaners throughout the United States without cumulative damaging effects or fatalities being reported.

Trichlorethylene is considered a little more apt to be dangerous than C_2Cl_4, although its M.A.C. rating is the same, because it is more volatile, about midway in this respect between the two above.

Stoddard solvent and the 140° F Solvent are rated as M.A.C. 500 ppm and because their volatiles are very low, this concentration of vapor would be exceedingly rare in a cleaning room atmosphere and then only at very high temperatures in a tightly enclosed space. Thus, these two are rated as non-toxic from the practical use standpoint.

5) What about Explosion and Fire Hazards?

The three synthetic solvents of which we have approved are nonflammable and their use is permitted by local fire regulations. In connection with fire hazards, however, the chlorinated solvents, when involved in a fire on the premises, usually will act as a fire extinguisher. Unfortunately, the heated vapors which do not support combustion may decompose to form phosgene, $COCl_2$, an extremely poisonous gas which, if breathed even in minute concentrations, might be lethal.

140° F solvent is moderately restricted by some municipal and state governments because of stringent fire safety regulations. These restrictions usually deal with fire wall construction isolating the washroom and work areas and amounts of solvents that can be stored on the premises.

Stoddard solvent is considered more of a fire hazard and restrictions on safety codes are more drastic than for the 140° F.

6) How do the Various Approved Drycleaning Solvents Compare as to Costs?

Costwise, petroleum solvents are priced in 50 gallon lots at about 30-35 cents per gallon. The chlorinated solvents run about $2.75 per gallon, while the fluorinated solvent is about three times that price. If purchased in gallon lots, especially as trade marked products, these prices are very much higher.

7) What Special Solvents are not Recommended for General Drycleaning Usage?

The special solvent classifications are not recommended for general drycleaning purposes for a number of reasons: for example, in the petroleum hydrocarbon class, gasolene, as known in the United States, kerosene, and certain more exquisitely refined fractions of such as benzine, contain low boiling fractions that are unsafe from the flammability point of view. Some of them contain noxious and odorous products that might cause trouble with fabrics in cleaning or with handling personnel.

A second class of hydrocarbons obtained principally from distillation of coal tars produce special solvents that are widely used for removal of paint, adhesives and other polymerized masses. These are designated by organic chemists as aromatic hydrocarbons. There are three related substances which are popular special solvents: first, benzene (not to be confused with benzine or lighter fluid, a low boiling petroleum fraction) with a chemical formula C_6H_6. This substance is very flammable, having a boiling point of about 80° C. It is highly toxic and cumulative, causing destruction of the blood cells. It is an extremely good solvent for very many things. It should be used with great care and caution. In an impure form it is known as benzol.

Toulene $C_6H_5CH_3$ is the second member of the series and is a popular substitute for benzene. Its impure form is known as toluol. This chemical is less toxic and less flammable than benzene perhaps because its boiling point is higher, about 110° C. It is rated as less active than benzene.

Xylene, with chemical formula $C_6H_4(CH_3)_2$ is the third member of the aromatic series. As usually purchased, xylol is a mixture of the three isomers of xylene, ortho, para and meta, each of which differs from one another in chemical structure, boiling points, toxicity and solvent power. Xylol is less volatile, less flammable, less toxic and lower in solvent power than toluol. Its boiling point ranges from 127 to 150° C.

Other occasionally used solvents not recommended for ordinary drycleaning work are ketones such as acetone (CH_3COCH_3), alcohols such as methanol (CH_3OH), esters such as ethyl acetate ($CH_3CO_2C_2H_5$) and a great variety of similar substances. Many of these have pleasant odors but may be toxic and are mostly highly flammable. In general, they are very special solvents and of course are not suitable for drycleaning but may be valuable additions for some particular purpose where they are compatible with the main cleaning medium. Often these substances are not safe for use on dye-

stuffs and before employment should be checked very carefully for effect on colors and on the fabric structure.

There are very many chlorinated hydrocarbons that have specific solvent powers. Two of these, chloroform and carbon tetrachloride have already been mentioned as not recommended. Of the numerous others, very few would be approved because of high toxicity ratings.

It is important that a conservator knows that chlorinated hydrocarbons may decompose in the presence of moisture and light to form among other products hydrochloric acid. In this case, the acid will dissolve in the water which will collect on top of the solvent, since these solvents are heavier. Its presence can be recognized by use of litmus paper and may be decanted off or absorbed into blotters readily. This is a relatively easy way of removing the objectionable strong acid before using. Furthermore, if the solvent is dried as suggested above and stored in the dark, hydrolyis later is unlikely.

Neither perchlorethylene nor trichlorethylene hydrolize appreciably and corrosion problems are rare in practice. This is probably due to the fact that the water, if any, is removed by special filters in the systems and the solvent is stored in light excluded tanks.

SECTION III. Additives.

What Additives are Needed for Optimum Cleaning in the Drycleaning Process?

In connection with the way that the drycleaning fluids work, we should recall some of their specific properties. These will be restated to emphasize the importance of certain additives that are required for best all around performance.

These requirements are best explained by the probable several steps in the drycleaning process. There are five of these which have been explained under the general theories of detergency in the immediately preceding paper in this series [6] and are listed again as follows: First, the cleansing medium must dissolve as many objectionable soils as possible; second, it should be capable of solubilizing, with the aid of certain additives, other hard to remove crusts and deposits; third, it should emulsify otherwise insoluble liquids or peptize solid masses; fourth, once these solid mases are broken up, the cleansing medium should be able to suspend these particles within the liquid; fifth, when suspension has been achieved, it is necessary to prevent flocculation until the particles can be removed from the cleaning scene.

As brought out earlier, dissolving effects are of two kinds, wet and dry. The drycleaning liquids, although their dissolving power is principally confined to non-polar fatty type substances, can dissolve minute quantities of polar and other water soluble soils because of absorbtion of exceedingly small amounts of water from the air in molecular form. This moisture is the first of the necessary additives for cleaning and can be controlled and modified by other important additives such as cosolvents and "drycleaning detergents". Either of these types of agents, which are discussed below, can distribute limited amounts of moisture into the solvent independently of the relative humidity of the air.

Natural air contact humidification of both the solvent and the fabric is a slow and haphazard occurrence, so addition by means of the moisture carrying cosolvents has become standard drycleaning practice. In the usual "charged" drycleaning operation containing a measured quantity of dry cleaning soap mixed with a little water (this mixture is called the charge) the three phases, fabric, solvent and air, usually come to the desired moisture equilibrium corresponding to 75-90% optimum air R.H. very rapidly. This is because all three phases are enclosed in a washing machine which quickly mixes and exposes all three phases to one another. As a consequence, if the air or solvent R.H. is measured by a hygrometer (an instrument designed for that purpose) the operator can detect when more charge should be added. In fact, this can be done automatically and most modern drycleaning plants are equipped with devices to do so.

It is very probable that most insoluble or resistant soils on the fabric are more or less hygroscopic and react to changes in the solvent relative humidity favorably.

What are "Drycleaning Soaps" and How do they Differ from Drycleaning Detergents?

The "drycleaning soaps" are not pure compounds and do not form solutions in the solvents. They were developed earlier in the history of dry cleaning but are not widely used now and have been generally replaced by drycleaning detergents.

There are three types of these "drycleaning soaps": paste, semi-paste, and liquid. They are mixtures of true water soluble soaps (not soluble in drycleaning solvents themselves), long carbon chain fatty acids (example: oleic acid, $C_{17}H_{33}COOH$, whose function is to disperse the true soap), perhaps some organic alkali (ammonium hydroxide, NH_4OH, Conc. or triethanolamine $[(C_2H_5O)_3N)]$, and a cosolvent such as butyl alcohol, C_4H_9OH, amyl alcohol, $C_5H_{11}OH$, cyclohexanol or hexalin, $CH_2(CH_2)_4CH_2OH$ and butyl cellosolve or ethylene glycolmonobutyl ether, $C_4H_9OCH_2CH_2OH$. The last two named seemed to be the most popular. The soap mixture also contains a small amount of the necessary moisture.

These cosolvents are put into the mixture for the purpose of quickly adjusting the cleansing medium R.H. to the desired solvent R.H. level independently of the room air R.H. and at the same time furnishing the needed moisture content equilibrium to the submerged fabric.

The "drycleaning soaps" have been superceded by drycleaning detergents for general use in the industry and very few modern plants use them any

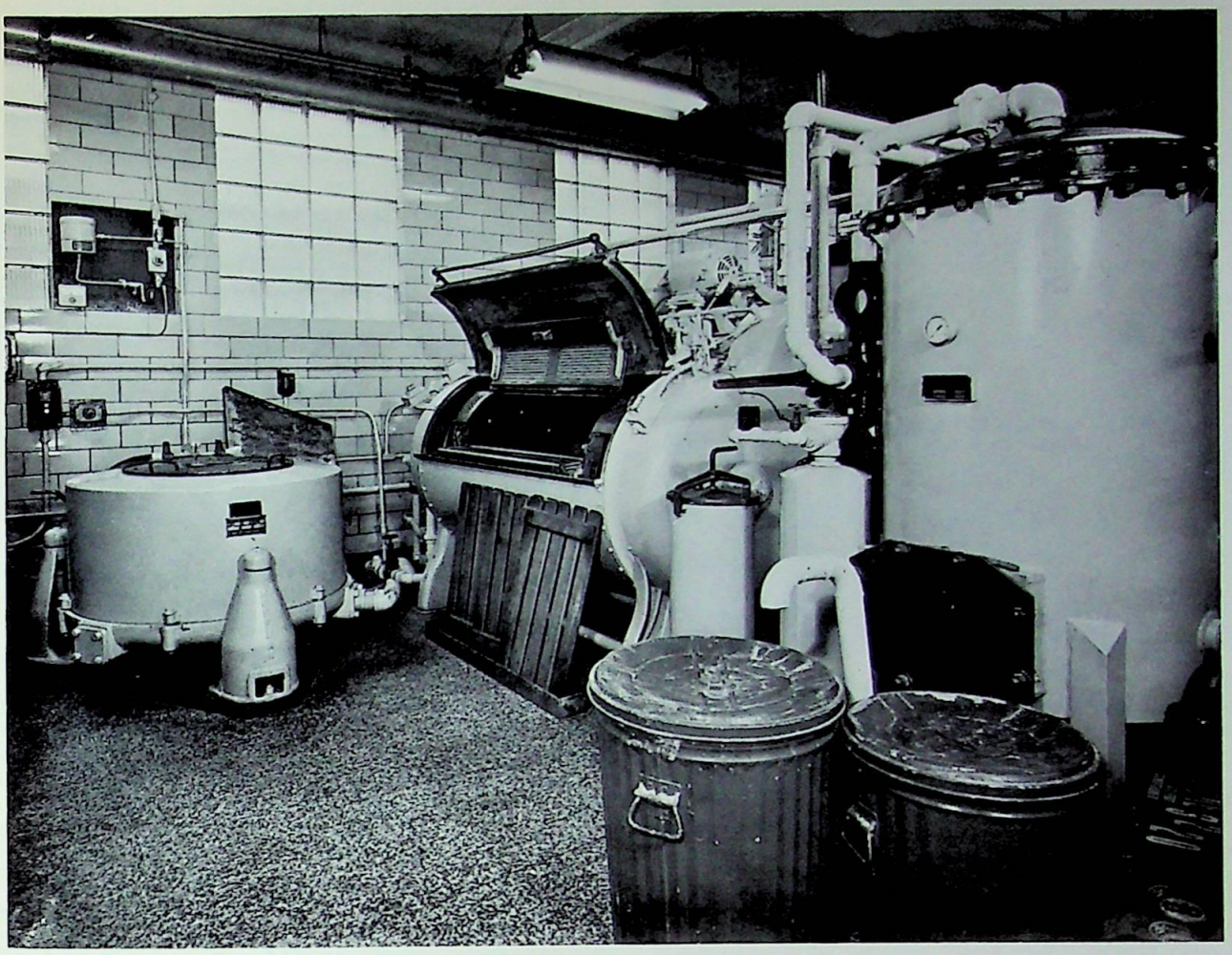

Figure 1 *Typical equipment for cleaning by petroleum solvents such as is used for instruction in the School for Drycleaners, National Institute of Drycleaning, Silver Spring, Maryland. From left to right: (a) Centrifugal extractor, (b) Large slow speed washing machine, and (c) Large capacity solvent filter*

more. The reasons are that they are hard to filter out of the used solvents and the free fatty acids build up in the systems to cause redeposition of soils. Furthermore, they may oxidize to produce vile smelling decomposition products. These "soaps", especially paste types, however are occasionally used for special soaking baths for redeposited soils and for gutter splash stains.

The function of the true soap in the mixture is probably that of penetration and solubilization of certain classes of soils and together with limited moisture and the fatty acid forms complex soil-soap-fatty acid-water micelles within the solvent system. Although larger in dimenions and mass than single molecules, a dispersion of these complex micelles probably approaches the appearance and distribution conditions of a true solution and may pass through a filter.

What are Some Important Characteristics of Drycleaning Detergents?

The "drycleaning soaps" have been generally superceded by drycleaning detergents which have many advantages over the "soap" mixtures. These drycleaning detergents differ from their wetcleaning counterparts, in structure mainly, by being compounds of longer carbon chains. They resemble one another because both contain the necessary hydrophylic (_0) and hydrophobic (_____) features
+ 24C's
in the molecule _____0 but in this case the latter is longer in proportion, twenty-four to thirty or more carbon atoms as compared to sixteen or eighteen in the usual water soluble detergent. This extra molecular length accounts for solubility in the solvent while the hydrophylic part of the mole-

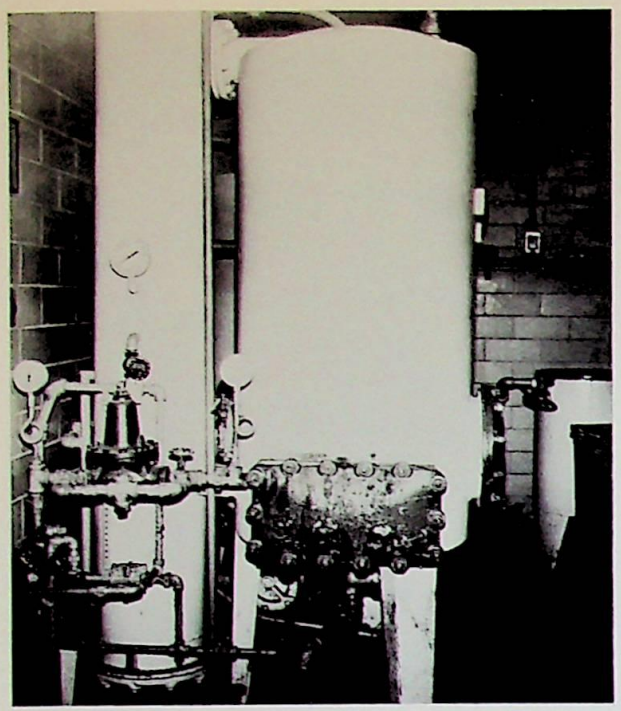

Figure 2 *A typical solvent still such as may be seen in the instructional plant of the National Institute of Drycleaning*

cule donates moisture carrying power and limited cosolvency to the detergent. Mainly these drycleaning detergents are either very nearly pure chemical compounds or mixtures of the same types. They may be anionic or nonionic in character. The anionic types may be metalic sulfonates or phosphates. The nonionic types may be ethylene oxide condensates or amine condensates. These last chemical groups are not as commonly used as the anionics. Appendices II and III provide trade names for a number of drycleaning detergents.

While both the drycleaning detergents and drycleaning soaps are able to suspend peptized carbonaceous or clayey soils if broken up into conveniently sized particles, they are not apt to provide spontaneous penetration into soil masses. One reason is that the available moisture is too meagre and is bound to the detergent molecule. The drycleaning fluids do not swell the fibers or the soils so that release and pulverization must be accomplished by mechanical action, principally.

Once the soil is dislodged and peptized, the particle may be further surrounded by a protective colloidal film which helps suspension. But if these particles are not removed from the cleaning scene quickly, flocculation of the particles will occur and the soil may redeposit on the fabric. When mechanical action is prolonged or is excessive, the energy within the solvent is converted into static electricity which in turn brings about flocculation and redeposition. This adverse electrical condition may be minimized by a polarized detergent and addition of an optimum amount of moisture. It is one of the reasons why the anionic detergents are popular in the drycleaning industry.

Even when flocculation is diminished, it is still necesary to get rid of the suspended soil particles quickly. This is done by exchanging the cleansing medium for fresh solution. In commercial cleaning, the contaminated solvent is replaced continuously and is filtered to remove the insoluble soils. A picture of such a filter is shown in Figure I. The filtrate is recirculated because costs would be prohibitive if the dirty solvent were to be thrown away. While there is some drycleaning detergent adsorbed on the insoluble particles of the soil retained on the filter, much of it remains in the solvent and returns to the cleaning system. In the case of the drycleaning soaps much more of a gel type complex is retained by the filters and clogging of the filter system is rapid.

In drycleaning museum textiles by hand methods when immersion processing is employed, the baths must be changed frequently to avoid some of the troubles mentioned above. The used solvent may be discarded if only a small quantity is involved, but in case of a gallon or more it should be saved in a separate receptacle for later filtering.

Where "drycleaning soaps" are used, the fatty acids, being soluble, build up in the solvent above their best concentration for soil removal and the quality of the cleaning in the reused solvent is lowered. The development of odors in this case has been mentioned. Plants using the soaps clarify their solvents by saponification of the fatty acids and by alkali treatment.

The drycleaning detergents do not require fatty acids in their formulation for soil removal and suspension. For this reason, fatty acid build up is not as serious a problem when they are used. However, there is always some fatty acid along with other soluble undesirable matter from body and other soil substances that will eventually concentrate in a refiltered drycleaning medium. When these contaminants become objectionable, it is necessary to separate them from the drycleaning solvent by distillation. Such a still is shown in Figure 2. This not only separates the undesirable substances, including fatty acids, but will remove the remaining detergent. A few substances that boil below the range of the solvent will also distil over with it but since these are usually of little or no effect, they may be neglected. Any extra water that comes over in the distillate may be removed by filtering the solvent through rag filters where the water is absorbed. Incidentally, this also removes some otherwise objectionable odor forming substances.

Other additives besides moisture, detergents and perhaps cosolvents, are for special treatments and include such chemicals as insect repellants, fungicides and other preservatives and are often applied in solutions or emulsions in drycleaning solvents. These last, however, have nothing in common with soil removal.

SECTION IV. Drycleaning Systems.

How Should a Textile Conservator go About a Project of Drycleaning a Fragile Specimen?

The logical steps in sequence in a job of drycleaning are:

1. The inspection and testing phase.
2. The decision phase in which selection of cleaning methods, equipment and the particular cleansing medium to be used is made.
3. Preparation of the specimen for cleaning.
4. The actual immersion phase.
5. Removal of excess solvent.
6. The drying phase.

Under What Conditions should Drycleaning be Considered as a Treatment for a Textile?

There are four major reasons for drycleaning a textile in preference to wetcleaning it. First, if by tests and inspection the dyes or colorants bleed or crock when treated with water and detergent solutions, it will usually withstand drycleaning. Whether it will or not should be checked, however, because sometimes painted articles will be softened or lost by solvent action. The test is done by applying a few drops of the various solvents to a selected area in miniature and after a short time to allow for penetration, blot or rub the area gently with a soft white cloth. If on inspection, the cloth shows smears or traces of color, then the particular painted or solvent affected colored areas must be covered with a "resist" treatment before cleaning. Ways of doing this are provided later herein.

A second case where a textile should be preferentially drycleaned is when the fabric and yarn structures are obviously badly oxidized or rotted. In this case, wetting with water and subsequent drying may contribute to further oxidation and drastic decomposition. The drycleaning solvents do not foster this oxidation effect and, if carefully prepared and handled, most specimens will not be weakened further.

Thirdly, shrinkage and felting is much less likely in drycleaning. However, there are cases where it might happen during the drying phase after the specimen is removed from the solvent bath. This point wil be explained when drying and deodorization are considered.

The fourth reason for selecting drycleaning is where there is a finish such as a glossy or starched surface as in a chintz or stiffened area which must be preserved. Often these finishes will not withstand wetcleaning but can be protected by a resist treatment of some kind. In this case, starch, linseed varnish or other sizings may be covered by a suitable substance insoluble to the cleansing medium before cleaning and afterwards recleaned by a special solvent to remove the coating.

In making a decision to dryclean any textile, one of the most important factors is to observe and judge the physical condition of the specimen. If it is obviously strong and not particularly worn, insect damaged or rotted from mildew, for example, it may withstand drycleaning in conventional drycleaning equipment where considerable mechanical action is employed. This consists of vigorous tumbling in a washing cycle of 10 to 30 miutes in the solvent and moisturized drycleaning detergent bath. As explained previously, this bath is usually continuously recirculated through a filter so as to dislodge and remove the insoluble soil as quickly as possible. The equipment used is generally an enclosed revolving horizontal cylinder which for safety and economy reasons is sealed from the room. (Figure 1b) The machinery is grounded electrically in order to remove excessive static electrical build up. This is of very great importance where petroleum solvents are used because of sparking possibilities and in the case of non-explosive type synthetic solvents it also helps to prevent soil redeposition. In either event, the use of anionic detergents helps this condition because the micelles act much like ions and are electrical static charge carriers from the solution to the grounded metal machinery system. This, by the way, suggests an alternate method of warning the operator of the condition of the charged solvent other than by its relative humidity condition as mentioned before. The electrical conductivity phenomenon is used to activate apparatuses for adding increments of detergent moisture "charges" during the recirculation operation.

Nearly all of these machines operate at a moderate revolving speed that reverses direction every eighteen or twenty revolutions. This produces a combination of tumbling of the fabric and jet flow of the solvent that effectively breaks up and loosens much of the soil rapidly and, coupled with constant replacement of the "charged" solvent, produces good cleaning. The tumbling and flexing action may be too drastic, however, for delicate or old and worn fabrics. In that case, individual pieces may be enclosed in net bags for protection. When this is done, cleaning may not be so successful.

This writer has overcome this damage tendency to a large extent by carefully laying the specimen to be cleaned between two layers of aluminum wire screening which is then stapled together. This sandwich is then rolled into a coil and fastened securely. This precaution permits circulation without excessive flexing as the machine revolves and reverses.

Extraction or removal of surplus liquid is the next step in the process. This is actually a continuation of soil removal by getting rid of remaining contaminated solvent. Most modern drycleaning machines change automatically from the reversing washing motion to high speed single direction revolving. At this time the inner cylinder which is a perforated metal basket acts as a centrifuge and high pressures on the fabrics may be built up as the liquid flies out through the perforations into the

outer closed containing shell where it is collected and drained away. The pressures and the haphazard crumpling of an unprotected textile will cause creasing and perhaps breaking of some fabrics and is a possible cause of damage. If the article is protected by the coiled screen as explained above, the creasing and damage is unlikely.

In older and perhaps obsolescent types of equipment developed for petroleum solvent, the washers are usually larger and longer and the extracting centrifuges are usually separate pieces of equipment. (Figure 1b) In this event, the work is transferred by hand from the washer to the extractor in which the basket whirls around a central vertical post. (Figure 1a) In loading this type, the various individual pieces may be placed carefully to avoid excessive damage and screen wire coils, if used, placed advantageously so as to minimize rupturing pressures. Equipment such as just described is shown in Figure 1.

Also on this older type of equipment, the washers can be operated intermittently at slower speeds to avoid excessive mechanical action.

The next step after the extraction operation is drying and deodorizing. In the most modern equipment, especially that used with synthetic solvents, drying is done in the same machine as the two previous operations. In this case the revolving perforated cylinder slows down in speed very greatly. This adjustment is made automatically by a timing device which turns on a supply of heated air and at the same time closes the liquid solvent system valves. If the machine is designed for synthetic solvents, the vapors are condensed and returned to the solvent system and the air may be recirculated. If designed for petroleum solvent cleaning, a much greater quantity of drying air is furnished in order to reduce the concentration of solvent vapors to a point where the mixture is too lean to explode. The vapors in this case are run to waste in the air because condensation does not pay and toxic hazards are extremely low. The stacks and ducts leading out of the drying facility should be kept free of lint, dust and obstructions to avoid possible fire hazards.

Because the heated air usually over dries the textiles, they may appear to be harsh and brittle after drying. This condition is more likely to be observed as a result of petroleum cleaning than from the synthetic solvents. The reason is that the petroleum solvents boil at a much higher temperature and evaporate much slower than the synthetics. Thus, in drying over the longer period more of the natural moisture content of the fibers is removed. This takes a longer time for natural replacement and the apparent dryness and lack of plasticity and flexibility is more noticeable. This can be restored quite easily by carefully steaming the textile.

Tumble drying as described above may cause wear and other possible damage because of long exposures to the tumbling, dropping and abrasion actions especially when dry. Also the combination of dry heat and mechanical flexing has been found to cause some woolen goods to felt and shrink. For these reasons, tumble drying is not advisable for most museum textiles.

Professional cleaners have overcome this objection by resorting to drying by suspending fragile articles in heated drying cabinets or rooms and in a current of warm air. While drying is slower, there is very little mechanical action on the specimens and flexing damage is very rare. Wool felting and shrinkage in this case is unlikely. As mentioned above, an excess of warm air supply and cleanliness of the air ducts, exhaust fans and stacks are important. Figure 3 shows a typical dryer of this type.

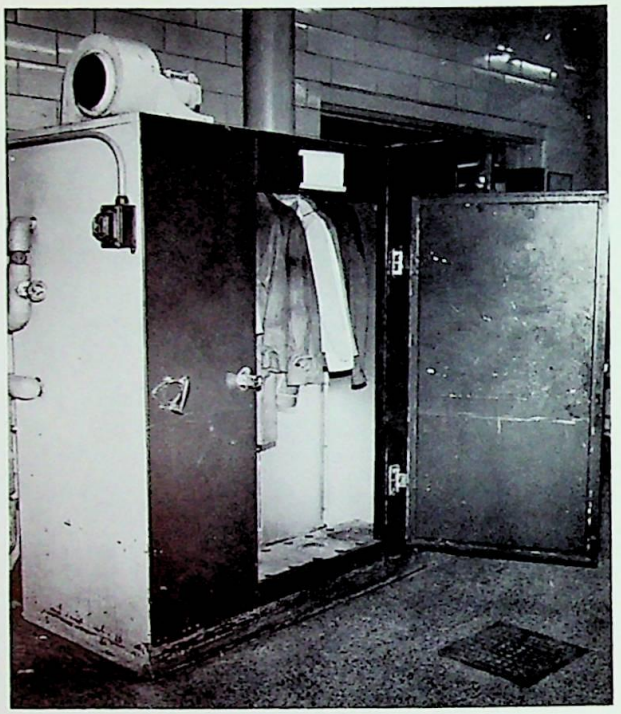

Figure 3 *A typical drying cabinet in use in the instructional plant of the National Institute of Drycleaning*

What are the Main Precautions to be Taken in Drycleaning Fragile Textiles by Hand?

Where it may be advisable to dryclean a very old and fragile textile fragment or article that would probably not withstand the necessary mechanical action described above, this author has used a system of manipulation by hand that has proven satisfactory. There may be many degrees of hand working, however, ranging from mere undisturbed soaking techniques through intermittent changing of solutions, sponging, brushing, tamping of the fabric face to vigorous squeezing and stirring of

the solvent on fabric piece in the bath. The choice and amount of mechanical action would depend on the estimated ruggedness of the fabric and the type and extent of the soiling.

In general, small fragments should be supported by a screening type material of plain or twill weave plastic fiber such as heavy Nylon*, Saran* or plastic covered fiberglass. It may be advisable to sandwich the specimen between two layers for complete stability. Sometimes, in order to keep the specimen from creeping between the layers, it must be held in place by a layer of fine silk crepelene on one or both sides also. In case the fabric shows evidence of fiber and yarn fragmentation, the supporting plastic should be a closely woven twill. In some cases, for ease in handling, the support fabric should be fastened to a wooden frame of stretcher.

According to this author's studies and experience, the most satisfactory drycleaning fluid for cleaning of museum textiles is 140° F flash point petroleum solvent. The reasons are that it is relatively safe from the fire and explosion hazard standpoints; it is practically nontoxic; can be purchased at a reasonable price; and is a versatile cleaning agent because it can be used for extended soaking baths. It does not promote oxidation of fibers and has little or no effect on all but a few unusual dyes. Its cleaning efficiency and safety can be increased by addition of small amounts of drycleaning detergents or "drycleaning soaps" plus a very little water.

In the absence of sophisticated cleaning machinery, batch system equipment may be improvised from any suitable tub or large pan. For a very large piece, it is even possible to construct a temporary vat of wood and line it with heavy plastic such as double layer of four mil (0.004 inch) polyethylene plastic sheeting. For calculating the solvent requirements of such a vat, a convenient approximate rate figure to use would be that for every square foot of area, two inches deep, about 1¼ gallons of liquid would be needed. Two inches would be the minimum convenient working or soaking depth.

When working with temporary or improvised equipment indoors, the temperature should be cool (no higher than about 75° F) and good ventilation should be provided. In case of accidental spills on the floor, one should know that the solvent vapors are very much heavier than air and mix quite slowly. If any explosive mixture were to be set up, which is unlikely, it would be in the bottom-most air layer. For this reason, electrical motors or other moving equipment on the floor, if not spark proofed, should be grounded. Ventilation outlets also should be located at floor level in this case.

In actual cleaning, there may be occasions when mere soaking is all that one can do for a very brittle or worn specimen. If it is a protein fiber fabric soiled by airborne or general use deposits, the detergent-moisture charge for soaking would be about 1¼ ounces of water per gallon (1% by volume) of liquid anionic special drycleaning detergent. This mixture would be used at the rate of about 5 oz. (liquid) per gallon of solvent. For soaking old textiles that have been buried, one may have to substitute "drycleaning soaps" in the same proportions. In either case, patience and time are very important and as much as twenty-four hours of contact may be required. Occasional gentle movements of the textile to bring fresh solution into contact is helpful. After soaking for a while, the solvent should be examined for clarity and color which would indicate progress of soil removal and whether or not a fresh solution would be required. After soaking, the specimen is drained, rinsed in clear solvent and drained again. Drying and deodorization usually take 24 to 72 hours, depending on the extraction method employed. These will be described later.

Where extreme precautions against handling damage are unnecessary, it is possible to speed up the processing and improve the soil removal results by wiping the fabric surfaces with sponges or brushing them with soft brushes to provide mechanical action for intimate contact of the solvent and for peptizing insoluble soils. Pumping the solvent through the supported fabric by alternate pressure and release of sponges is a gentle and effective way of producing mechanical action also. Each problem will probably require a different method or combination of more than one. At any rate when the solution on examination appears to be discolored, it may have to be exchanged and the operation repeated.

One way of making a test for soil removal is by comparing the appearance of the original solution against that of the used solution. For this, one needs a test tube of each at the same depth level viewed at a white background for comparison.

Rinsing and draining in clear solvent after the mechanical treatment phase is required for complete soil removal.

Extraction of excess solvent may be by vertical draining or more rapidly by blotting up the excess in absorbent materials such as clean white absorbent paper or cloth. However, these blotters, when saturated, should be dried by themselves in open air before being discarded. Although the solvent is composed almost exclusively of non-drying oils, some soils are of unsaturated or drying types and in oxidizing might build up in a confined space enough temperature to cause a spontaneous combustion. This is unlikely, but can be avoided by the above precaution. It also admonishes us to see that the dry-cleaning fabrics are completely dried before sealing into packages, for example.

In the fabric drying phase, the time factor varies with how well the work has been extracted. Other factors that affect the drying rate are temperature, the amount of surface exposed to the air and the rate of airflow past the surface or through the fabric. In commercial drying cabinets (see Figure 3) especially constructed for the purpose, two to six hours of time may be required. This, of course, depends on the weight or thickness of the fabric. For natural drying, the estimate of 24 to 72 hours

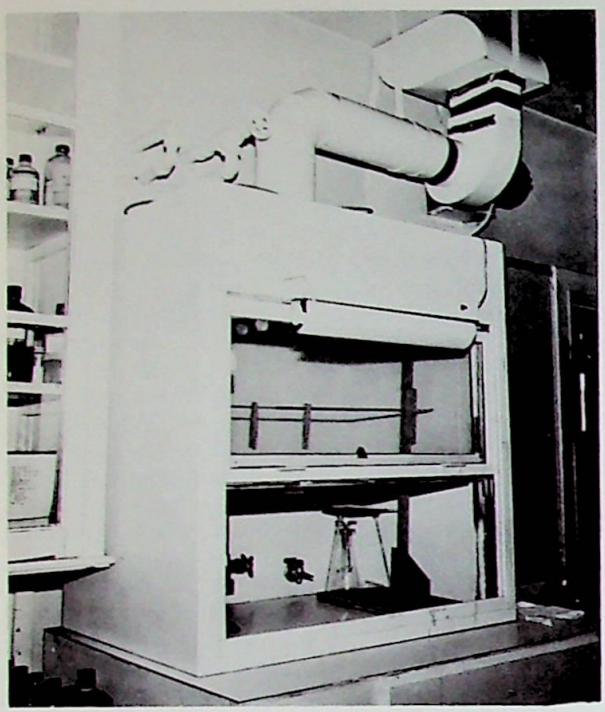

Figure 4 *A cleaning cabinet which was designed for the Conservation Laboratory of the Textile Museum*

would hold for most pieces. Very weak fabrics would be dried horizontally on supporting fabrics. Others may be suspended vertically for better air circulation.

Since there is no actual overwetting of the fibers, catalytic oxidation because of the excess moisture is improbable. Likewise, overdrying and reduction of the natural moisture content, that sometimes causes harshness and brittleness of the fibers in heat dried cases, cannot happen.

Should it be necessary to use a synthetic solvent for drycleaning, where solvent fumes might be objectionable and hazardous, the Textile Museum Laboratory has built an enclosed cabinet which is under fan suction and the operator works without being exposed to the toxic. Such a cabinet is illustrated by Figure 4 and is suitable for work on small specimens. For larger pieces, a bigger cabinet of similar plan would be required and, in that case, perchlorethylene could be used safely employing a similar cleaning routine as described for 140°F cleaning.

* Trade marked names.

NOTES

[1] James W. Rice, Principles of Textile Conservation Science, No. V, "The Characteristics of Soils and Stains Encountered on Historic Textiles", *Textile Museum Journal*, Vol. 1, No. 3, pp. 14, 15.

[2] N. J. Berg, Wetcleaning, p. 1, National Institute of Drycleaning, Silver Spring, Maryland, 1945.

[3] See Note 1, p. 14.

[4] For specifications, see G. P. Fulton, Applied Science for Drycleaners, pp. 382-389, National Institute of Drycleaning, Silver Spring, 1951.

[5] Leopold Sheflan and Morris B. Jacobs, *Handbook of Solvents*, Table 2, Probable Safe Concentration Limits of Exposure for Vapors, pp. 12-14. D. Van Nostrand Co., Inc., 1953 (as revised).

[6] James W. Rice, Principles of Textile Conservation Science, No. VII, "Characteristics of Detergents for Cleaning Historic Textiles", *Textile Museum Journal*, Vol. II, No. 1, pp. 23-37.

The author is indebted to the National Institute of Drycleaning for cooperation and permission to photograph equipment and for reference material used in this article.

APPENDIX I

List of 140° F petroleum type drycleaning solvents (probably trade marked) with manufacturers' names published by the National Institute of Drycleaning in *Bulletin T-427*, January 1967.*

Amsco #140 Solvent—American Mineral Spirits Co., Division of the Union Oil Co. of California

Amsco 140 L Solvent—American Mineral Spirits Co., Western South Gate, California

Apco 140—Apco Oil Corporation, Oklahoma City, Okla.

Sur-Dri 140 F—Barton Solvents, Inc., Des Moines, Iowa

Bronco #140 Solvent—Bronco Solvents and Chemical Co,. Division of Ashland Oil and Refining Co., St. Louis, Mo.

140 Flash Naptha—Dominion Chemical Co., Petersburg, Virginia

Drake 140 Flash Solvent—Drake Petroleum Co., Chicago, Illinois

140° F Solvent—Globe Solvents Co., Inc., Philadelphia, Penna.

G S #140 Special—Grow Solvent Co., Detroit, Mich.

Hess 140 Flash Naptha—Hess Oil & Chemical Corp., Perth Amboy, N. J.

Howell 140 T—Howell Refining Co., San Antonio, Texas

Varsol 4 (140 F)—Humble Oil & Refining Co., Houston, Texas

Inland 140 F Solvent—Inland Oil & Chemical Corp., Baltimore, Md.

Napoleum 140 Solvent—Kerr-McGee Oil Industries, Inc., Oklahoma City, Okla.

Solvasol 140—Mobil Oil Co., New York, N. Y.

Shell Sol 140—Shell Chemical Co., New York, N. Y.

Espesol 350 (140 F)—Signal Oil & Gas Co., Houston, Texas

Skellysolve T (140 F)—Skelly Oil Co., Tulsa, Okla.

140 F Solvent—Washington Petroleum Products, Inc., Washington, D.C.

* *Bulletin T-427* referred to above also contains similar information concerning other solvents which, although discussed in this *Journal*, were, for reasons stated, not recommended for general cleaning of museum textiles. The author has received permission from the National Institute of Drycleaning to publish the above list.

APPENDIX II

List of trade mark named drycleaning detergents found among several thousand detergents of all sorts in McCutcheon's "Detergents and Emulsifiers" *1967 Annual*, published by John W. McCutcheon, Inc., 236 Mt. Kemble Avenue, Morristown, New Jersey, 07960. This list is furnished merely as a guide for inquiries in case more special detailed information as to particular properties for conservation problems are needed. For most general purposes, the classification and data furnished by the *Annual* is much more comprehensive than the following simple tabulation. It is probable that many of the products listed below are patented substances sold to compounders and distributors only and for that reason may not be available on the retail market under the names in this particular table.

Product Name	*Manufacturer*
Alkapent B.D. 40	Weyland Chemical Division
Alkapent B.D. 80	Weyland Chemical Division
Alkapent B.D. 100	Weyland Chemical Division
Alkapent D.HP 60	Weyland Chemical Division
Alkapent M 60	Weyland Chemical Division
Alrosol 0	Geigy Industrial Chemicals
Alrosperse 100	Geigy Industrial Chemicals
Alrosperse PC	Geigy Industrial Chemicals
Atlas G-711	Atlas Chemicals
Calimulse	Pilot Chemical Co.
Dupanol G	E. I. du Pont de Nemours & Co.
Emcol 5138A	Witco Chemical Co. Inc., Organic Chemical Division
Ethofats	Armour Industrial Chemical Co.
Ethomids	Armour Industrial Chemical Co.
Fosterage W. D.	Textilana Corporation
Nitrene N.O.	Textilana Corporation
Gefac P. E. 510	General Analine and Film Corp. Dyestuff and Chemical Division
Gafamide C.D.D. 518	General Analine and Film Corp. Dyestuff and Chemical Division
Hallco C-430, C-431	C. P. Hall Co. of Illinois
Hyonics P.E. 40	Nopco Chemical Company
Hyonics P.E. 90	Nopco Chemical Company
Hyonics P.E. 100	Nopco Chemical Company
Hyonics P.E. 120	Nopco Chemical Company
Marco Amide 00	Maher Color & Chemical Co.
Marco Amide RC	Maher Color & Chemical Co.
Ninate 415	Stepan Chemical Co.
Petrosul 744 LC	Pennsylvania Refining Co.
Rokyl A.I.S.	Rozilda Laboratories, Inc.
Reuterg I.P.A.	Finetax, Inc.
Schercoterge I.D.S.	Scher Brothers, Inc.
Surfonic M 10	Jefferson Chemical Co., Inc.
Surfonic M 60	Jefferson Chemical Co., Inc.
Synthronite D.C.	Synthron, Inc.
Synotex	Dixo Co., Inc.
Tergitol N.P. 14	Union Carbide Corp., Chemicals Division
Tergitol N.P. 15	Union Carbide Corp., Chemicals Division
Tergitol N.P. 16	Union Carbide Corp., Chemicals Division
Tergitol X.D.	Union Carbide Corp., Chemicals Division
Triton G R 7	Rohm and Haas Co.
Triton X-45	Rohm and Haas Co.
Wysol 200	Wye Industries
Wysol 10	Wye Industries

APPENDIX III

Tabulation of a number of drycleaning detergents by trade name and supplier. These were furnished the author by the Laboratories of the National Institute of Drycleaning, Silver Spring, Maryland, to which he expresses his appreciation and thanks therefor.*

Name	*Manufacturer or Compounder*
Bellamine	Bellar Booth (Canada)
C. D. L.	Hope Chemical Company
Dow-Per Charger	Dow Chemical Company
Dyanite Double Str. w/br.	Adco Company
Dyanite Double Str. wo/br.	Adco Company
Economy Concentrates	Economy Concen. Company
Econoterge 50	Eastern Color and Chemical Co.
Econoterge 75	Eastern Color and Chemical Co.
Econoterge 100	Eastern Color and Chemical Co.
"886"	R. R. Street & Co.
Flash Concentrate Soap	Clarkson Laboratories
Flo Brite	Stamford Chemical Co.
Imperial	Anscott Co.
Kyro E. O.	Proctor & Gamble Co.
Lanadol	Böhme Fettchemie (Germany)
Master Kleen	Kleen Test Laboratory
Neupro C.B.S. Special	Neupro Co.
Neupro Hygene for Perc	Neupro Co.
Neupro Hygene for Stodd.	Neupro Co.
Pace Perk	Caled Products
Pass Up +	Cowles Chemical Co.
Perk Sheen 324	Adco Co.
Plaid	Signal Chemical Co.
Rite Charge	Cowles Chemical Co.
Sanitone 8808	Emery Industries
Secapur PLV	Büsing & Fasch (Germany)
Shell D.C. 4 Heigh Charge	Shell Company
D.C. 44 Super Charge	Smiths Chemical Co.
Speed Tex	Textile Chemical Co.
Staticol	R. R. Street & Co.
Super C	Caled Products
Super Lite	Stamford Chemical Co.
Super Perc	Adco Co.
Super Stat 100	Diamond Chemical Co.
Tempo AV	Stockhausen (Germany)
Thrif-D-Lux	Stamford Chemical Co.
Tri Cleen	Anscott Co.
XXX	Adco Co.
Zo Kleen	Coleman Products

* Some of the above drycleaning detergents are suitable for perchlorethylene systems only; others are specially designed for petroleum solvents, and a few are for both types.